PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : F02B 57/06, 57/10

A1

(11) International Publication Number: WO 91/06752

(43) International Publication Date: 16 May 1991 (16.05.91)

(21) International Application Number: PCT/AU90/00196

(22) International Filing Date: 11 May 1990 (11.05.90)

(30) Priority data:
PJ 7265 6 November 1989 (06.11.89) AU

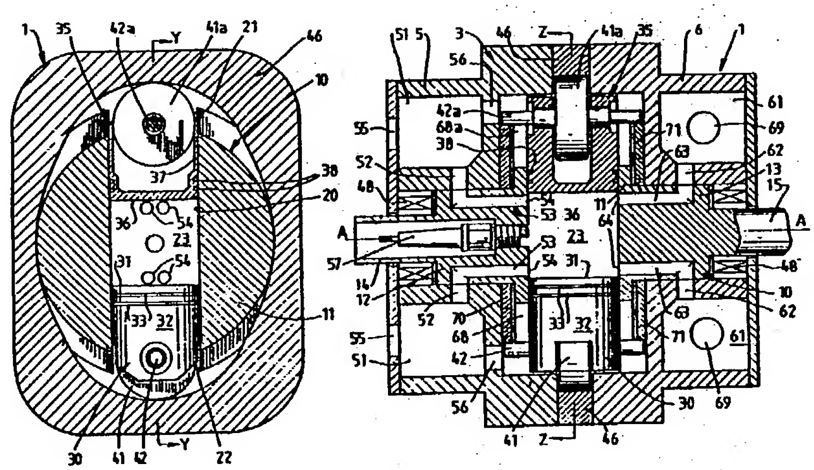
(71)(72) Applicant and Inventor: HILTON, Barry, Edwin [GB/AU]; 141 Seaford Road, Seaford, VIC 3198 (AU).

(74) Agent: GRIFFITH HACK & CO.; 2nd Floor, 601 St. Kilda Road, Melbourne, VIC 3004 (AU).

(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BG, BR, CA, CH, CH (European patent), DE*, DE (European patent)*, DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GB, GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, MW, NL, NL (European patent), NO, RO, SD, SE, SE (European patent), SU, US.

Published
With international search report.

(54) Title: INTERNAL COMBUSTION ENGINE



(57) Abstract

An internal combustion engine has a cylinder block (10) mounted for rotation about an axis A-A in an outer casing (3), the cylinder block (10) having a diametrical bore therethrough forming a cylinder (20) which houses a pair of pistons (30, 35) positioned with their crowns (31, 36) facing one another so as to define therebetween a combustion chamber (23). Attached to the skirt (32, 37) of each piston (30, 35) via a gudgeon pin (42, 42A) is a cam follower (41, 41A) which engages an oval-like cam (46) fixed to the outer casing (3) about the circumference of the cylinder block (10). On combustion of an air-fuel mixture within the combustion chamber (23), the pistons (30, 35) are forced outwardly of the cylinder (20) which in turn causes the cylinder block (10) to rotate about axis A-A through the agency of the cam (46) and followers (41, 41A). Power output is taken from a shaft (15) co-axial with axis A-A which extends from a boss (13) attached to the cylinder block (10). The engine can run on either a two or four-stroke cycle with either spark ignited petrol or a high compression diesel ignition system.

* See back of page

DESIGNATIONS OF "DE"

Until further notice, any designation of "DE" in any international application whose international filing date is prior to October 3, 1990, shall have effect in the territory of the Federal Republic of Germany with the exception of the territory of the former German Democratic Republic.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MR	Mauritania
BE	Belgium	GA	Gabon	MW	Malawi
BF	Burkina Faso	GB	United Kingdom	NL	Netherlands
BG	Bulgaria	GR	Greece	NO	Norway
BJ	Benin	HU	Hungary	PL	Poland
BR	Brazil	IT	Italy	RO	Romania
CA	Canada	JP	Japan	SD	Sudan
CF	Central African Republic	KP	Democratic People's Republic of Korea	SE	Sweden
CG	Congo	KR	Republic of Korea	SN	Senegal
CH	Switzerland	LI	Liechtenstein	SU	Soviet Union
CI	Côte d'Ivoire	LK	Sri Lanka	TD	Chad
CM	Cameroon	LU	Luxembourg	TG	Togo
DE	Germany	MC	Monaco	US	United States of America
DK	Denmark				

INTERNAL COMBUSTION ENGINE

TECHNICAL FIELD

This invention relates to internal combustion engines.

DISCUSSION OF THE PRIOR ART

There are many forms of internal combustion engines which have been developed over the years and these will be well known to those persons skilled in the art. Today, the traditional Otto engine is still the most common internal combustion engine in use.

In the Otto engine, the combustion of a fuel/air mixture produces heat energy which is converted to linear kinetic energy by the motion of a piston. This linear energy is then converted to rotational energy with the use of a connecting rod and a crankshaft. Finally, a load is driven by the circular motion. This method of converting the energy to different forms before it is finally used to drive the required load is very inefficient due to the large number of moving parts and the consequential

disadvantages, such as friction. Furthermore, the engine is unbalanced, resulting in a number of additional components being required to balance the engine so that it will operate with minimum vibration. A flywheel is also required to store rotational energy which can be used to turn the engine during the non-firing stages of the process.

In Otto engine design, the piston remains at the top dead centre (TDC) for only a fraction of a second. Consequently, the fuel mixture is usually ignited before the piston reaches TDC and the fuel mixture burns while the piston is travelling. This results in significant loss of potential power. In order to get the most use of the combustion process, it would be ideal if the combustion process could be completed while the piston is at TDC, hence resulting in the highest possible pressure within the combustion chamber. Furthermore, in the conventional engine, to prevent back pressure when purging the cylinder on the exhaust stroke, the exhaust valve must be opened before reaching bottom dead centre (BDC). This results in a significant wastage of energy.

From the above it is clear that energy is lost for a number of reasons. Combustion must commence before the piston reaches TDC, energy is lost in compressing an already expanding gas, maximum pressure is not being obtained during combustion since combustion is not completed at constant volume, energy is lost in the form of heat because a large portion of the cylinder walls are exposed to the burning fuel mixture, and further energy is lost because the exhaust valve opens prematurely.

Over the past century there have been a number of different configurations and implementations of the internal combustion engine. All have attempted to overcome many of the disadvantages of the Otto engine, but few have

been successful enough to succeed in the market place. A number of engines have incorporated opposing pistons, usually in an attempt to reduce vibration, but in all situations the cylinder has remained stationary while various connecting rods, crankshafts and camshafts are employed to convert the energy produced by combustion into useful mechanical energy.

The engine as disclosed in US patent 4,334,506, is one example of an engine design with oppositely positioned pistons. The engine employs a stationary cylinder block comprising pistons with crowns facing one another and an outer cam which rotates around the cylinder block. This engine requires a number of springs and other parts to ensure the pistons remain in contact with the cam of the engine. These springs provide only uniform tension and are unable to compensate for changes in speed of the pistons thus, at low speeds the tension is excessive and at high speeds the tension is too low, which causes the pistons to jump. The engine requires a take off drive to connect a load to the engine and an additional cowling to prevent accidental contact with the rotating cam. This design is very complex with minimal access to components which must be mounted through the central core. All input and output facilities must also be provided through the central static shaft, thus necessitating a substantial bearing surface to allow access.

The significant inefficiencies of existing internal combustion engines are obvious. The intrinsic design prevents the most efficient employment of the internal combustion process. The complex structures, large number of components, requirement for precise engineering, assembly and adjustment makes these engines inefficient, costly and vulnerable to failure.

It is an object of this invention to provide an engine which can reduce costs, size, complexity, weight, wastage of energy and lead to the reduction of pollution.

SUMMARY OF THE INVENTION

According to the present invention there is provided an internal combustion engine comprising

a cylinder block having a cylinder therein, the cylinder block being rotatable about a major axis thereof, the cylinder being open at each end and extending generally radially with respect to the major axis of the cylinder block;

a pair of pistons each having a crown, the pistons being at least partially disposed within the cylinder in opposed relation with the crowns facing one another to define a combustion chamber in which an air/fuel mixture may be combusted, the piston being arranged for reciprocating movement between a first position in which the crown are close together and a second position in which the crowns are furthermost apart;

a pair of followers each being associated with a respective piston and being operatively connected thereto so as to be capable of extending from a respective open end of the cylinder; and

a stationary cam which is engageable by the followers so that they may move therealong, the arrangement being such that as the pistons move from the first position to the second position the followers move along the cam so that the cylinder block is caused to rotate.

Preferably the cam has oppositely disposed complementary shaped first cam surface portions which are engageable by the respective followers when the pistons move between the first and second positions. The cam surface portions are so configured that the forces produced by the pistons moving from the first to the second positions causes rotation of the cylinder block.

Preferably these cam surface portions are diametrically opposed. The cam may further comprise complementary-shaped and oppositely disposed cam surface portions which are engageable by respective followers for guiding the pistons from the second position to the first position as a result of rotation of the cylinder block.

The pistons may be of a standard or generally known form. For example, they may comprise a crown as referred to above and a skirt extending away from the crown. Piston rings may be provided as is known in the art.

Each of the followers may be in the form of a thrust bearing and may comprise a roller element which is mounted for rotation about an axis parallel to the major axis of the cylinder block. Preferably the followers are operatively connected to the skirt of the piston and in one form each roller bearing is operatively connected to the skirt of a respective piston by means of a gudgeon pin which extends through the skirt of the piston the roller being disposed intermediate the walls of the skirt.

Fuel delivery means and exhaust discharge means may be provided for introducing fuel to the combustion chamber, and after burning thereof, for exhausting the combusted gases through the exhaust means. A fuel igniter such as a spark plug or the like may be provided to initiate burning of the fuel.

The engine may include an outer casing for rotatably supporting the cylinder block. Suitable bearings may be provided which can be carried by the outer casing for supporting the cylinder block. In one form, the casing comprises two parts which are securable together with the cam being secured between the two parts.

The cylinder block may include a main body portion which contains the open ended cylinder. The main body portion may take any suitable shape and may, for example, be circular in cross section with respect to its major axis with the cylinder being diametrically disposed radially of

that major axis. The cylinder block may further include a pair of bosses disposed on opposite sides of the main body portion and disposed co-axially with the major axis. Preferably one of the bosses is operatively connected to or forms part of the output member. Preferably the bosses of the cylinder block are rotatably supported in the main casing of the engine by the bearings referred to earlier.

In one embodiment the fuel delivery means may include an inlet port which delivers the fuel to the combustion chamber and valve means for selectively controlling the delivery of fuel to the inlet port. In one form, the fuel delivery means comprises a delivery chamber disposed within the main casing of the engine the delivery chamber having a delivery port therein which delivers fuel from the chamber to the inlet port via a transfer channel which is preferably disposed within one of the bosses of the cylinder block. Valving is effected by the selective opening and closing of the delivery port as the boss rotates; that is as the boss rotates the transfer channel becomes in fluid communication with delivery port thereby permitting fuel to enter the combustion chamber through the inlet port at selected periods.

In this particular embodiment, a back pressure port may be provided which provides communication between the cavity between the piston and the outer casing and the delivery chamber. The arrangement is such that the pressure built up as the pistons move to their outer position is used to force fuel through the inlet port.

According to this particular embodiment the exhaust discharge means may be similar of configuration to that of the fuel delivery means. For example, it may include a discharge port for discharging gases from the combustion chamber and valve means for selectively controlling the discharge. The exhaust discharge means may comprise a discharge chamber disposed within the main casing with a discharge port and a transfer channel as is the case for the fuel inlet means.

Valving is effected in the same manner, that is by rotation of the boss. Preferably the inlet means is disposed in one side of the casing with the exhaust means in the other side of the casing.

According to another embodiment of the invention the incoming fuel charge is delivered via a suitable valve arrangement to the cavities between the pistons and the outer casing. The fuel charge is compressed within these cavities and delivered to the combustion chamber via a transfer valve system and delivery ports. Preferably the delivery ports are also used as discharge ports from which exhaust gases are discharged from the combustion chamber.

The use of the one set of ports firstly for delivering the fuel charge to the combustion chamber and then discharging the exhaust gases from the combustion chamber provides several advantages. Firstly the exhaust gas is maintained at a relatively low temperature because of the cooling effect of the incoming fuel charge. This has the advantage that the engine may be run without the need for external cooling systems. Secondly the incoming fuel charge is preheated by the parts thus creating greater turbulence in the combustion chamber and enhancing complete combustion.

Preferably the delivery ports comprises a plurality of slots disposed around the cylinder so that port size can be maximized, and thus minimise the amount of movement by the pistons to open and close the ports. Furthermore, contamination of the fresh fuel charge is minimized due to its even spread into the cylinder.

Preferably the new fuel charge is delivered into one end of the chamber and the exhaust gases escape from the other end. The exhaust valve is cut off just prior to the new charge escaping through the exhaust port. The engine is therefore completely purged of burnt gas and very little if any of the new charge is lost.

Furthermore, an inlet valve member may be provided together with a check valve such as a reed valve to ensure no loss of charge back towards the fuel input as a result of high back pressure.

The cam may be in the form of a rigid member having a continuous tracking surface on an interior surface thereof, the followers being adapted to move along the tracking surface as the cylinder block rotates. Preferably the cam comprises a rigid ring-like member which is operatively connected to the main casing of the engine. The precise shape of the cam surface may vary depending on the particular parameters required to be met, such as, for example, the time required for exhaust and fuel intake.

The engine may further include secondary cam means which, under certain circumstances, can direct the pistons to their second position. During normal operation of the engine, the combustion of the fuel causes the pistons to move towards the second position. Prior to combustion, however, (that is when the engine is started), the centrifugal force created by rotation of the cylinder block may not be sufficient to move the pistons. As such, a secondary cam means may be provided. Such secondary cam means may comprise a pair of cams disposed on each side of the pistons which are engageable with a pin which conveniently is an extension of the gudgeon pin for mounting the roller bearing to the piston. Preferably the secondary cams are of complementary shape to the cam surface on the primary cam.

The gudgeon pins are adapted to be received in slots in the cylinder block wall. In one arrangement the slots may be open at the peripheral outer end of the cylinder block. In another embodiment the slots are closed at the outer end i.e. the slots terminate short of the outer end. This latter arrangement ensures uniform expansion of the cylinder block and inhibits seizure of pins within their associated slot due to concentrated expansion in the weaker area of the slots.

In a preferred form the engine operates by combustion of a liquid or gas fuel mixture combined within the combustion chamber compressed and ignited. The resultant energy thus released forces the two pistons apart towards their second position. The energy transmitted from the two movable pistons forces the attached followers against opposed first surface portions of the fixed cam. The tangential shape of the surface forces the cylinder block to rotate around its major axis. After the cylinder block has been forced to rotate through an angle of 90 degrees and the pistons are in the fully extended second position at either end of the cylinder, the second surface portions of the cam then force the pistons back into the cylinder as the cylinder block continues to rotate as a result of its own inertial momentum through a further 90 degrees. The combustion chamber has now received a fresh charge of fuel which is compressed by the inner movement of the pistons is then ready to repeat its combustion expansion and compression cycles through the remaining 180 degrees of rotation.

As will be appreciated, the engine in its preferred form uses two power cycles per revolution with the use of only one cylinder and consists of only one moving part other than the piston assemblies.

DESCRIPTION OF THE DRAWINGS

In order that the invention may be more fully described, various embodiments will be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a cross-sectional view of an internal combustion engine forming a first embodiment of the present invention taken along the lines Z-Z of Figure 2,

Figure 2 is a cross-sectional view of the engine shown in Figure 1 taken along the lines Y-Y of Figure 1,

Figure 3 is a cross-sectional view taken along the lines 3-3 of Figure 4 illustrating an internal combustion engine that forms a second embodiment of the present invention,

Figure 4 is a cross-sectional view of the engine shown in Figure 3 taken along the lines 4-4 of Figure 3,

Figure 5 is an exploded perspective view illustrating the association of a cylinder block and pistons of the engine,

Figure 6 is a partially cut away perspective view of the cylinder block with parts removed for clarity,

Figure 7 is an exploded perspective view of primary and secondary cams that form part of the engine,

Figure 8 is a perspective view of the cylinder block illustrating its association with the cams,

Figure 9 is a plan view of the cylinder block,

Figure 10 is an end elevational view of the block in the direction of the arrow Z of Figure 9,

Figure 11 is a cross-sectional view taken along the lines C-C of Figure 10,

Figure 12 is a cross-sectional view taken along the lines F-F of Figure 9,

Figure 13 is a cross-sectional view taken along the lines E-E of Figure 9,

Figure 14 is a cross-sectional view taken along the lines D-D of Figure 9,

Figure 15 is an elevational view taken along the arrow Y of Figure 9,

Figure 16 is an elevational view taken along the arrow X of Figure 9,

Figure 17 is a cross-sectional view taken along the lines B-B of Figure 9,

Figure 18 is a cross-sectional view taken along the lines A-A of Figure 9,

Figure 19 is schematic illustrations of the operation of the engine, and

Figure 20 is a geometric representation of the cam profile and firing sequence of the internal combustion engine when operating on a two-stroke cycle.

The internal combustion engine which is illustrated in the drawings that accompany this specification in summary comprises a cylinder block 10 rotatably mounted in an outer casing. The cylinder block has an elongate open ended cylinder 20 which houses a pair of piston assemblies 30 and 35, positioned with their crowns facing one another to define a combustion chamber. The opposite end of each piston is associated with a cam follower 41, 41A that engages a fixed cam 46 that is secured to the outer casing. On combustion of an air/fuel mixture within the combustion chamber, the pistons are forced to reciprocate outwardly of the cylinder which in turn causes the cylinder block to rotate about the outer casing through the agency of the cam and cam followers. Power output is taken from the rotating cylinder block. The engine can run on either a two or four-stroke cycle with either spark ignited petrol or a high compression diesel ignition system.

Two embodiments are described with reference to Figures 1 and 2, and 3 and 4 respectively. The same reference numerals are used for like components.

The engines (1), as realised in the two embodiments, includes a stationary outer casing (3) comprising two shell-like sections (5 and 6). The outer casing confines the working components of the engine. The cylinder block (10), shown in greater detail in figure 5 and 6, is the main moving component of the engine and is

mounted inside the outer casing (3). The cylinder block (10) comprises a circular main body (11) and a pair of bosses (12, 13) located coaxially on either side of the main body. The cylinder block (10) is mounted so that it is free to rotate about an axis A-A. Each of the bosses is further extended by shafts (14, 15) which are also coaxial with the axis A-A. The cylinder block is mounted to rotate within the outer casing with the aid of bearings (48) which support the shafts in the casing. A cylinder (20) is disposed within the cylinder block (10) such that the cylinder extends diametrically through the cylinder block and has open ends 21 and 22 on the circumference of the main body (11).

A pair of pistons (30, 35) is disposed in opposite relation within the cylinder (20) with their crowns (31, 36) facing each other. The space between the two crowns (31, 36) thus forms the combustion chamber (23) of the engine. The pistons (30, 35) are arranged for free movement within the cylinder (20). The pistons used are of a design commonly used in conventional internal combustion engines. Each piston includes a crown (31, 36), a skirt (32, 37) and piston rings (33, 38). Attached to each of the pistons is a follower (41, 41a) which is mounted to the skirt (32, 37) of each piston by means of gudgeon pins (42, 42a). The followers are in the form of thrust bearing rollers which rotate around axes parallel to the axis A-A. The followers (41, 41a) are positioned to face out of the cylinder openings (21, 22) so that they are able to ride on the stationary cam (46). The cam (46) is of a oval-like shape, with the exact shape of the oval being specifically design for the particular operation of the engine. The cam is mounted onto the outer casing (3) and surrounds the circumference of the main body of the cylinder block.

Ideally, the followers (41, 42a) remain in constant contact with the cam, thus as the cylinder block (10) rotates about its own axis, the pistons (30, 35) will move in a reciprocating fashion towards each other and away from each other, within the confines of the cylinder (10), while the followers remain in contact with the cam. The cam is shown in more detail in figure 7.

Slots (68, 68a) are provided in the cylinder wall. The ends of the gudgeon pins (42, 42a) are adapted to pass through the cylinder walls by extending through these slots. The ends of the slots confine the motion of the pistons.

In normal operation, the combustion process within the combustion chamber (23) and the centrifugal acceleration of the pistons will produce sufficient pressure to force the followers against the cam. When no combustion is taking place, such as at startup, a situation could arise where the pistons may move inwards and consequently the followers will lift off the cam. In order to ensure that the followers remain in constant contact with the cam surface, secondary cams (70, 71) are located on either side of the cam (46), as shown in figures 7 and 8. The secondary cams are external of the cylinder block and are bolted to the outer casing (3) and may be a extensions of the cam (46). The secondary cams engage with the protruding ends of the gudgeon pins (42, 42a) of each piston and, together with the cam (46), confines the pistons to move within the cylinder (20) in a predetermined way in constant contact with the cam. The secondary cams (70, 71) ensure that the pistons move away from each other when required, while the cam (46) urges the pistons towards each other. Output from the engine is obtained from the shaft (15) extending from the other boss (13).

A spark plug (57) is provided to ignite the air/fuel mixture in the combustion chamber (23). The spark plug is mounted within the centre of one of the bosses (12) and shafts (14) of the cylinder block (10), thereby extending outside the engine. This allows for easy access to the spark plug when required. When the fuel is diesel, such a spark plug will not be required since high compression of the air/diesel mixture will cause ignition.

The air/fuel delivery and exhaust gas removal in the first embodiment will now be described with reference to figures 1 and 2. The air/fuel mixture enters the engine through a casing inlet port (55). The air/fuel mixture initially enters into a fuel delivery chamber (51) where it remains until it needs to be transferred to the combustion chamber (23). The cylinder (20) is provided with an inlet port (54) within the wall of the cylinder. There is a inlet passage (53) within the cylinder block (10) which extends along one of the bosses (12) of the cylinder block from the delivery chamber (51) towards the inlet port (54). As the cylinder block rotates, a delivery port (52), at the delivery chamber end of the inlet passage (53), is selectively opened to the deliver chamber (51) allowing the air/fuel mixture to pass from the delivery chamber (51), through the delivery port (52), along the inlet passage (53) and into the combustion chamber (23) via the inlet port (54). By carefully positioning the delivery port (52), it is possible to determine the exact time of letting the fuel mixture into the combustion chamber, and also the length of time of the transfer.

A low-grade supercharger can be created to force the fuel mixture into the combustion chamber by including a back pressure port (56). The pressure created behind the outwardly moving pistons is enough to force the air/fuel mixture from the delivery port (51) towards the combustion chamber.

An exhaust gas removal means, similar to the fuel delivery means, is used to remove the resulting exhaust gases after the combustion of the air/fuel mixture within the combustion chamber. The exhaust gases leave the combustion chamber (23) through an outlet port (64) which is located within the wall of the cylinder. The gases then pass along an outlet passage (63), through a discharge port (62) into a discharge chamber (61). Again, the discharge chamber (61) and the combustion chamber (23) are in communication only within certain periods of time as determined by the positioning of the discharge port (64) along the circumference of one of the bosses (13). The exhaust gases are then free to leave the engine via a casing outlet port (69). The embodiment shown in figures 1 and 2 has two set of fuel delivery means and two sets of exhaust gas removal means. This ensure that a maximum rate of transfer cam be achieved.

The second embodiment, as shown in figures 3 and 4, differs form the first embodiment in the way fuel delivery and exhaust gas removal is achieved. The air/fuel mixture enters the engine via a casing inlet port (90) from where it passes through a delivery passage (80), an inlet valve (81), a transfer passage (82) and a transfer valve (89) to a cavity region (85). The cavity region (85) is defined as the region between the casing (3) and the cylinder block (10). The air/fuel mixture is compressed within the cavity region as a result of the outward motion of the pistons (30, 35). At the required point in time, an inlet passage (86), which is located along on of the bosses (13) of the cylinder block (10), is opened to the cavity region (85), resulting in the air/fuel mixture flowing from the cavity region to the combustion chamber (23) via transfer ports (87). Figures 5 and 6 show these components in more detail. Rotation of the cylinder block and the inward

movement of the pistons close the transfer ports. After the combustion of the air/fuel mixture the pistons are forced apart, resulting in the transfer ports (87) opening again. The exhaust gases leave the combustion chamber (23) via the transfer ports (87), a outlet passage (92), an exhaust passage (91) and out of the engine through a discharge outlet (88).

The operation of the engine will now be described with reference to figures 19 and 20. Apart from the fuel delivery and discharge of exhaust gases, both embodiments operate in a similar manner. The engine operates by employing the internal combustion engine principle. That is, a liquid or gas air/fuel mixture is confined, compressed and then ignited. The resulting expansion due to combustion of the air/fuel mixture is converted to mechanical energy which is employed to drive a load.

During operation, the air/fuel mixture is delivered to the combustion chamber (23) by either of the valve systems previously described. Similar to a conventional 2-stroke engine, both inlet (54) and outlet ports (64) of the first embodiment, and transfer ports (87) of the second embodiment, are bored through the side of the cylinder (20) so as to be open when the pistons (30, 36) are at the outer ends of their travel. In addition to these ports, the associated inlet, transfer and exhaust valving are machined into the two bosses (12, 13) mounted on either side of the cylinder block (10). Ports are bored through the casing (3) and machined to fit exactly over the two bosses (12, 13) to form a sliding valve system. As the cylinder block (10) rotates the fuel delivery openings in the bosses are so arranged as to open only when the exhaust gases have been released. Likewise, the exhaust openings in the bosses are designed to close when the air/fuel mixture is injected into the combustion chamber(23).

During the inward travel of the pistons, the inlet valves commence to open. The air/fuel mixture is drawn in, through a carburettor, past a check valve, through the inlet valve and into the engine cavity surrounding the cylinder block (10). The cavity surrounding the cylinder block is so small that just about all the air/fuel mixture is forced into the combustion chamber when the transfer valve opens. In the conventional 2-stroke engine the cavity in the sump area is relatively large so that the transfer pressure is reasonably low. In the engine which is the subject of this invention this back pressure is high enough to act as a low grade supercharger.

Referring to figures 10 and 20, the air/fuel mixture is transferred into the combustion chamber (23) when one of the pistons is at position A. The ports into the combustion chamber are open until point B is reached. This particular position is shown in figure 19d. From point B to point C the pistons are moving inwards, resulting in the air/fuel mixture being compressed. For the entire travel from point C to point D the pistons are at TDC since the radius of the cam (46) remains constant. This is shown in figure 19e. A spark provided by the spark plug (57) ignites the air/fuel mixture and the mixtures burns while at constant volume. See figure 19a. The resulting energy, thus released, forces the two diametrically opposed pistons apart and toward each extreme of the open ended cylinder. The energy transmitted to the two movable pistons forces the followers (41, 41a) against the identically opposed inclined sections of the fixed cam (46). The shape of the cam forces the cylinder block to rotate around its own axis from position D to E. This is shown in figure 19b. During this stages E to G of the cycle the burned air/fuel mixture is exhausted and the combustion chamber is purged. After the cylinder block has

been forced to rotate so that the pistons are at their extreme from each other, as in figure 19c, energy remains in the form of inertia of the cylinder block. The inertia of the cylinder block causes the cylinder block to continue rotating and the shape of the cam force the pistons together.

The combustion chamber, having now taken a fresh charge of air/fuel mixture, consequently compresses the air/fuel mixture by the inner movement of the pistons and is ready to repeat the cycle. It should be note that the entire cycle is completed within a rotation of 180 degrees of the cylinder block, that is, two cycles can be completed within one full rotation of the cylinder block.

There are many significant improvements incorporated in the engine to control exhaust emission, improve the cooling problem and reduce fuel consumption.

(a) The engine uses a double acting revolving valve system that ensures correct metering of fuel mixture and prevents the release of fuel into the atmosphere, thus overcoming one of the major disadvantages of the conventional two stroke engine.

(b) Fuel is forced into one end of the combustion chamber by its own inbuilt supercharger action, whilst exhaust is ejected from the other end, thus purging the combustion chamber completely.

(c) Multiple porting cut around the cylinder wall prevents fuel contamination and ensures fast delivery and exhaust.

(d) The same set of cylinder ports may be used, first for transfer and then for exhaust; the ports being cooled directly by the incoming fuel mixture, creating greater turbulence in the cylinder and thus enhancing complete combustion.

(e) Because of flexability in cam design a constant volume area can be incorporated at TDC, thus the engine will make minimum contribution to pollution as it is possible to burn very lean mixtures in constant volume areas as well as to burn the fuel more completely at a faster rate than has hitherto been possible. Burning of lean mixtures results in better emission management and less tendency to misfire. High thermal efficiency means that less fuel will be used to meet the same power needs.

There are no con rods, no crank shaft, no springs, no external flywheel, no balancing elements, no poppet type valves or associated timing gear, no distributor and no critical parts to adjust or to slip out of timing. There is one moving part with two free unconnected pistons. With four power strokes to one in the Otto cycle, greater thrust efficiency and low mechanical resistance, the engine should be considerably more powerful than any conventional internal combustion engine. Yet, despite the obvious differences and advantages - it uses similar technology and can utilize most of the automotive industry tooling that is currently in use.

The versatility of the engine allows for considerable flexibility in design. The engine can be operated either as a wet sump or a dry sump arrangement. Futhermore, it can run on either highly volatile or low grade fuels. The design could also be varied for suitable fuel injection, supercharging, turbocharging and diesel operation. Likewise, the design could be easily modified for operation so as to fire once per revolution (similar to a conventional 4-stroke engine) in addition to the above described firing of twice in one revolution (similar to a conventional 2-stroke operation). A number of these engines can be incorporated to run back-to-back. A number of cylinders in different planes within the same cylinder

block can provide a multiple cylinder, multiple combustion chamber engine. Likewise, more than one cylinder can be incorporated in the same plane so that more than two pistons define a single combustion chamber. Cam design flexibility also allows the engine to be designed for a particular purpose, such as a high-speed low-torque application or a low-speed high-torque application or even constant speed applications without compensating features such as torque converters. It is an important feature of the cam that, within certain limits, any desired velocity profile and any acceleration/deceleration curve can be designed into the cam.

Finally, it is to be understood that the inventive concept in any of its aspects can be incorporated in many different constructions so that the generality of the preceding description is not to be superceded by the particularity of the attached drawings. Various alterations, modifications and/or additions may be incorporated into the various constructions and arrangements of parts without departing from the spirit and ambit of the invention.

CLAIMS

1. An internal combustion engine comprising

a cylinder block having a cylinder therein, the cylinder block being rotatable about a major axis thereof, the cylinder being open at each end and extending generally radially with respect to the major axis of the cylinder block;

a pair of pistons each having a crown, the pistons being at least partially disposed within the cylinder in opposed relation with the crowns facing one another to define a combustion chamber in which a fuel mixture may be combusted, the pistons being arranged for reciprocating movement between a first position in which the crowns are close together and a second position in which the crowns are furthermost apart;

a pair of followers each being operatively connected to a respective piston so as to be capable of extending from a respective open end of the cylinder; and

a stationary cam which is engageable by the followers so that they may move therealong, the arrangement being such that as the pistons move from the first position to the second position the followers move along the cam so that the cylinder block is caused to rotate.

2. An internal combustion engine according to claim 1, wherein the engine includes an outer casing for rotatably supporting the cylinder block.

3. An internal combustion engine according to either claim 1 or claim 2, wherein the the cylinder block comprises a main body of circular cross-section, with respect to the major axis of the cylinder block, the cylinder being diametrically disposed in the main body radially of the major axis.

4. An internal combustion engine according to claim 3, wherein the cylinder block includes a pair of bosses disposed on opposite sides of the main body and disposed coaxially with the major axis of the engine block.

5. An internal combustion engine according to claim 4, wherein at least one of the bosses is operatively connected to or forms part of an output member.

6. An internal combustion engine according to claim 4 or 5, wherein each of the bosses of the cylinder block are rotatably supported by the outer casing of the engine.

7. An internal combustion engine according to any one of the preceding claims, wherein each of the followers comprise a roller element which is mounted for rotation about an axis parallel to the major axis of the cylinder block.

8. An internal combustion engine according to claim 7, wherein the pair of followers are operatively connected to the respective piston by means of a gudgeon pin which extends through at least a part of the piston and the centre of the roller element.

9. An internal combustion engine according to any one of the preceding claims, wherein the cam comprises oppositely-disposed complementary-shaped portions which form an endless loop and are engageable by the followers when the pistons move between the first and second positions, such that the cam is so configured that energy produced by the combustion of the air/fuel mixture forces the pistons outwards from the first position to the second position which causes rotation of the cylinder block as the followers move along the cam, and the cam guides the followers so as to move the pistons from the second position to the first position as a result of the further rotation of the cylinder block due to the inertia of the cylinder block.

10. An internal combustion engine according to any one of the preceding claims wherein an auxiliary drive means positioned externally of the cylinder block urges the pistons to the second position.

11. An internal combustion engine according to claim 10 when dependent on claim 8, wherein the auxiliary drive means comprises a pair of stationary secondary cams, each cam having a cam surface that engages one end of the respective gudgeon pin to, in use urge the piston to the second position.

12. An internal combustion engine according to claim 11, wherein the secondary cam surfaces are of complementary shape to the surface of the cam.

13. An internal combustion engine according to claim 11 or 12, wherein the gudgeon pins are adapted to pass through slots in the cylinder wall to engage on the outside of the cylinder wall.

14. An internal combustion engine according to any one of the preceding claims, wherein the the engine is provided with a fuel igniter, such as a spark plug, to ignite the air/fuel mixture.

15. An internal combustion engine according to any one of the preceding claims, comprising a fuel delivery means for introducing the fuel mixture to the combustion chamber and exhaust discharge means for exhausting the combustion chamber after combustion of the air/fuel mixture.

16. An internal combustion engine according to claim 15, wherein the fuel delivery means includes an inlet port within the wall of the cylinder which delivers fuel to the combustion chamber and a first valve means within the cylinder block for selectively controlling the delivery of the air/fuel mixture to the inlet port.

17. An internal combustion engine according to claim 16, wherein the fuel delivery means is comprised of a delivery chamber, the delivery chamber having a casing inlet port through which the fuel mixture flows from the outside of the engine into the delivery chamber and a delivery port through which the fuel mixture may pass from the delivery chamber to an inlet passage; the inlet passage being able to deliver the fuel mixture from the delivery chamber to the inlet port.

18. An internal combustion engine according to claim 17 when dependent on claim 4, wherein the delivery chamber is disposed within the engine but outside the cylinder block and the inlet passage is disposed within one of the bosses of the cylinder block such that valving is effected by the selective opening and closing of the delivery port as the cylinder block rotates, resulting in the inlet passage becoming in fluid communication with the delivery port thereby permitting the fuel mixture to enter the combustion chamber from the

delivery chamber through the inlet port and along the inlet passage at selected periods.

19. An internal combustion engine according to claims 17 or 18, wherein the engine is provided with a back pressure port which enables communication between a cavity between the piston and the outer casing and the delivery chamber.

20. An internal combustion engine according to any one of claims 15 to 19, wherein the exhaust discharge means includes an outlet port within the wall of the cylinder for discharging exhaust gases from the combustion chamber and a second valve means for selectively controlling the discharge of the gases.

21. An internal combustion engine according to claim 20, wherein the exhaust discharge means comprises a discharge chamber, the discharge chamber having a discharge port through which the exhaust gases may pass from an outlet passage to the discharge chamber and a casing outlet port through which the exhaust gases may pass from the discharge chamber to the outside of the engine; the outlet passage being able to to deliver the exhaust gases from the outlet port to the discharge chamber.

22. An internal combustion engine according to claim 21 when dependent on claim 4, wherein the discharge chamber is disposed within the engine but outside the cylinder block and the outlet passage is disposed within one of the bosses of the cylinder block such that valving is effected by the selective opening and closing of the discharge port as the cylinder block rotates, resulting in the outlet passage becoming in fluid communication with the discharge port thereby permitting exhaust gases to be removed from the combustion chamber to the discharge chamber through the outlet port and along the outlet passage at selected periods.

23. An internal combustion engine according to claim 22, wherein the fuel delivery means is disposed in one boss and the exhaust discharge means is disposed in the other boss.

24. An internal combustion engine according to claim 15, wherein the air/fuel mixture is delivered from the outside of

the engine via a casing inlet port to cavities between the casing and the cylinder block, such that the air/fuel mixture is compressed within the cavities and delivered to the combustion chamber via a transfer valve system and transfer ports.

25. An internal combustion engine according to claim 24, wherein the transfer ports are also used to discharge exhaust gases from the combustion chamber through an outlet and a discharge passage to the outside of the engine.

26. An internal combustion engine according to either claim 24 or 25, wherein the transfer ports are comprised of a plurality of slots disposed around the cylinder wall.

27. An internal combustion engine according to any one of claims 24 to 26, wherein the valve system is provided with a check valve, such as a reed valve, to ensure no loss of the fuel mixture back toward the source of the fuel mixture as a result of high back pressure.

28. An internal combustion engine substantially as described herein with reference to and as illustrated in the accompanying drawings.

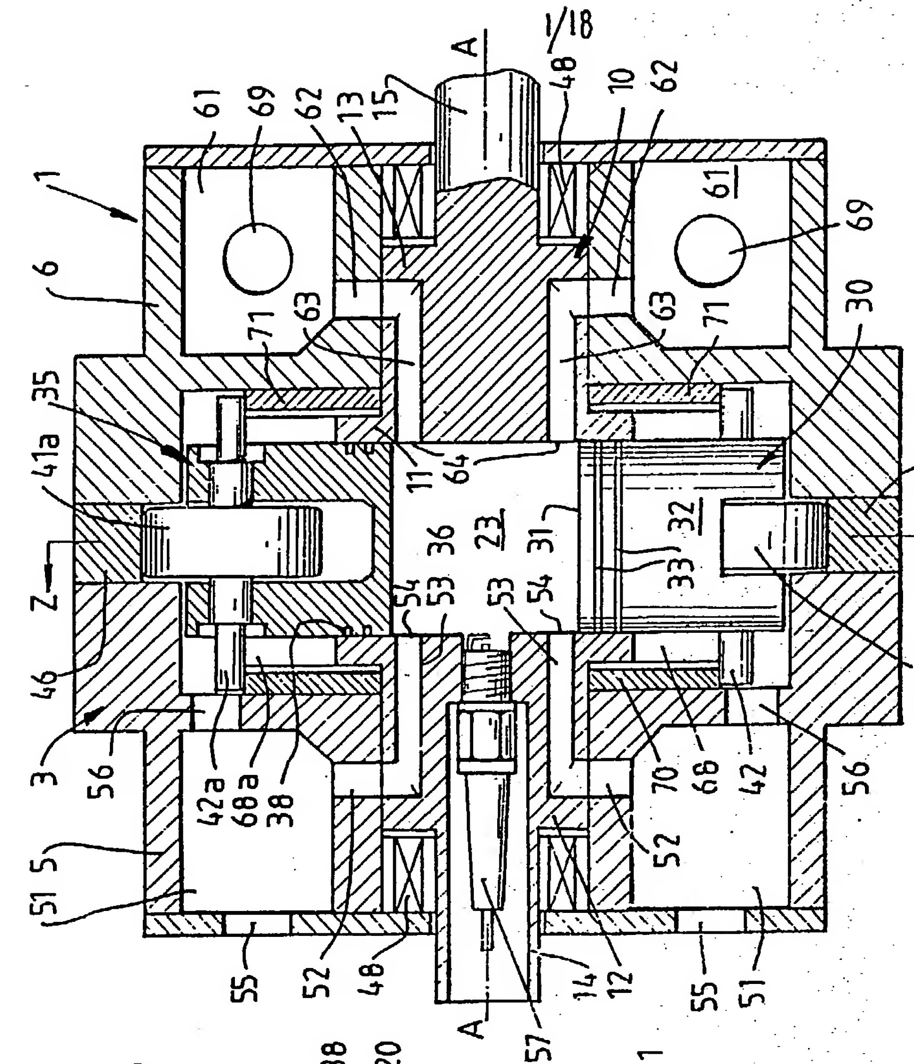


FIG. 2.

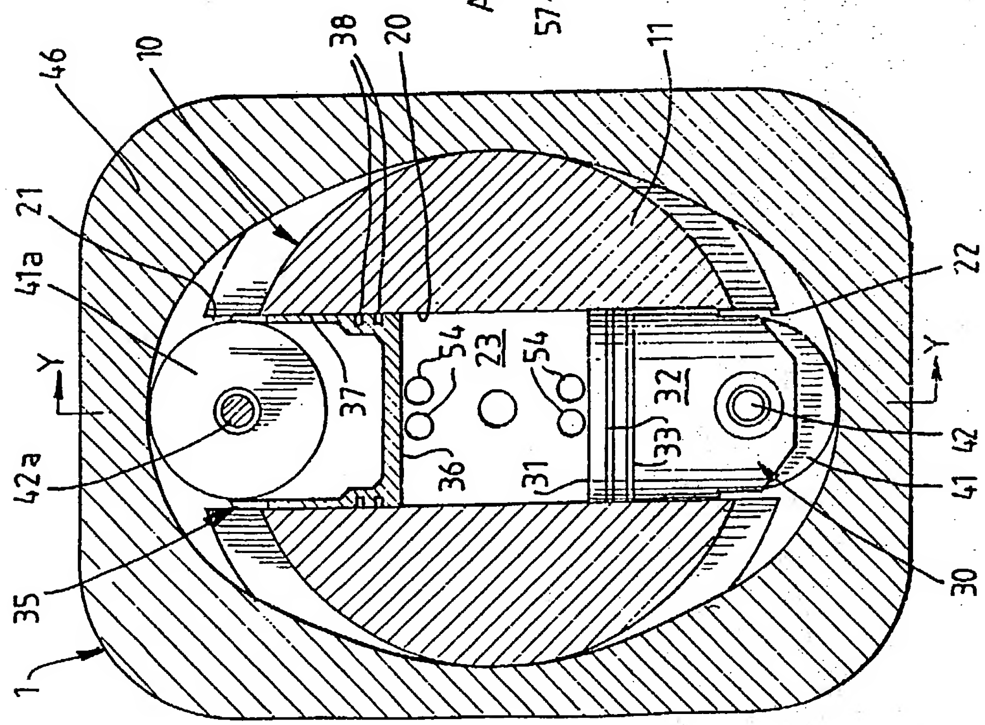


FIG. 1.

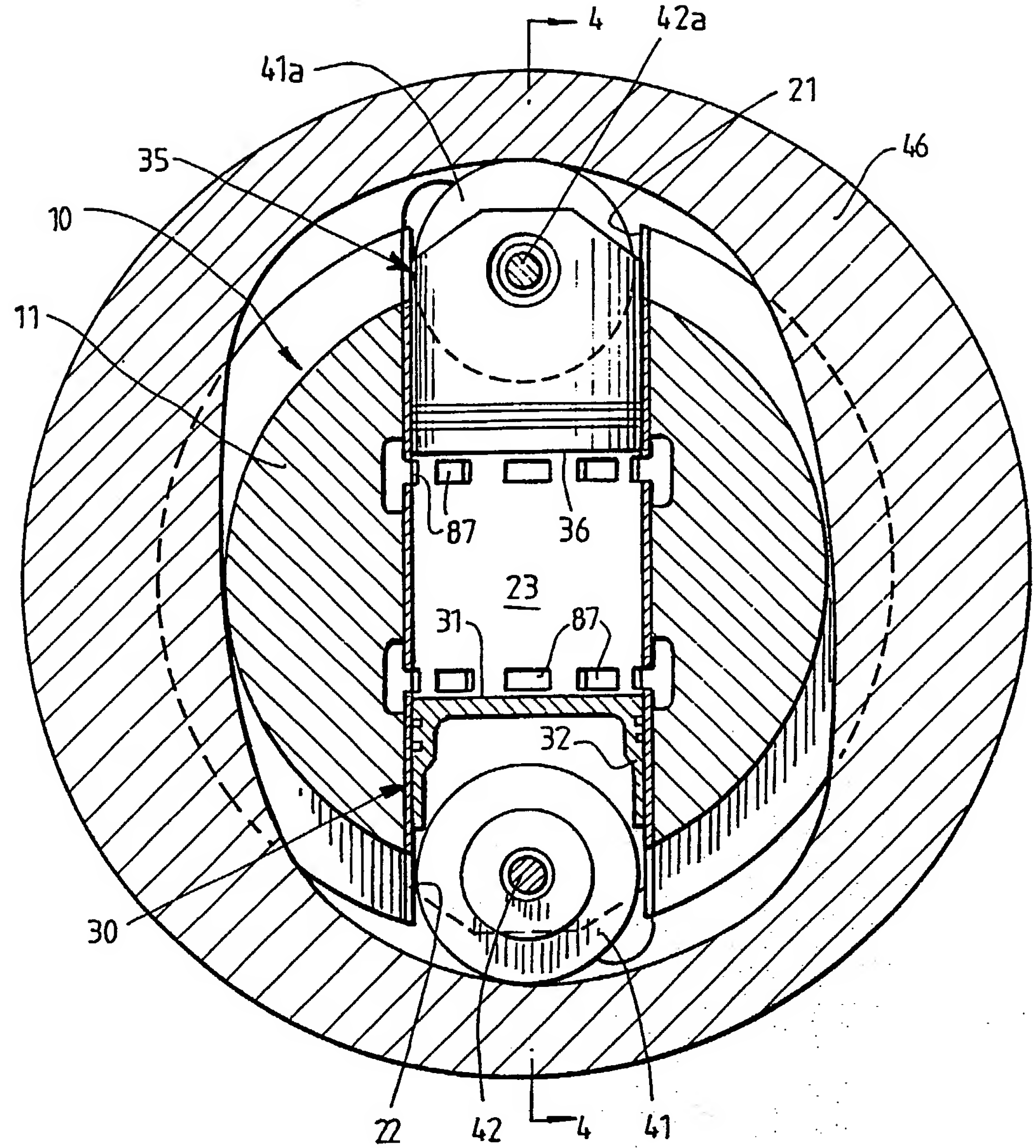


FIG. 3.

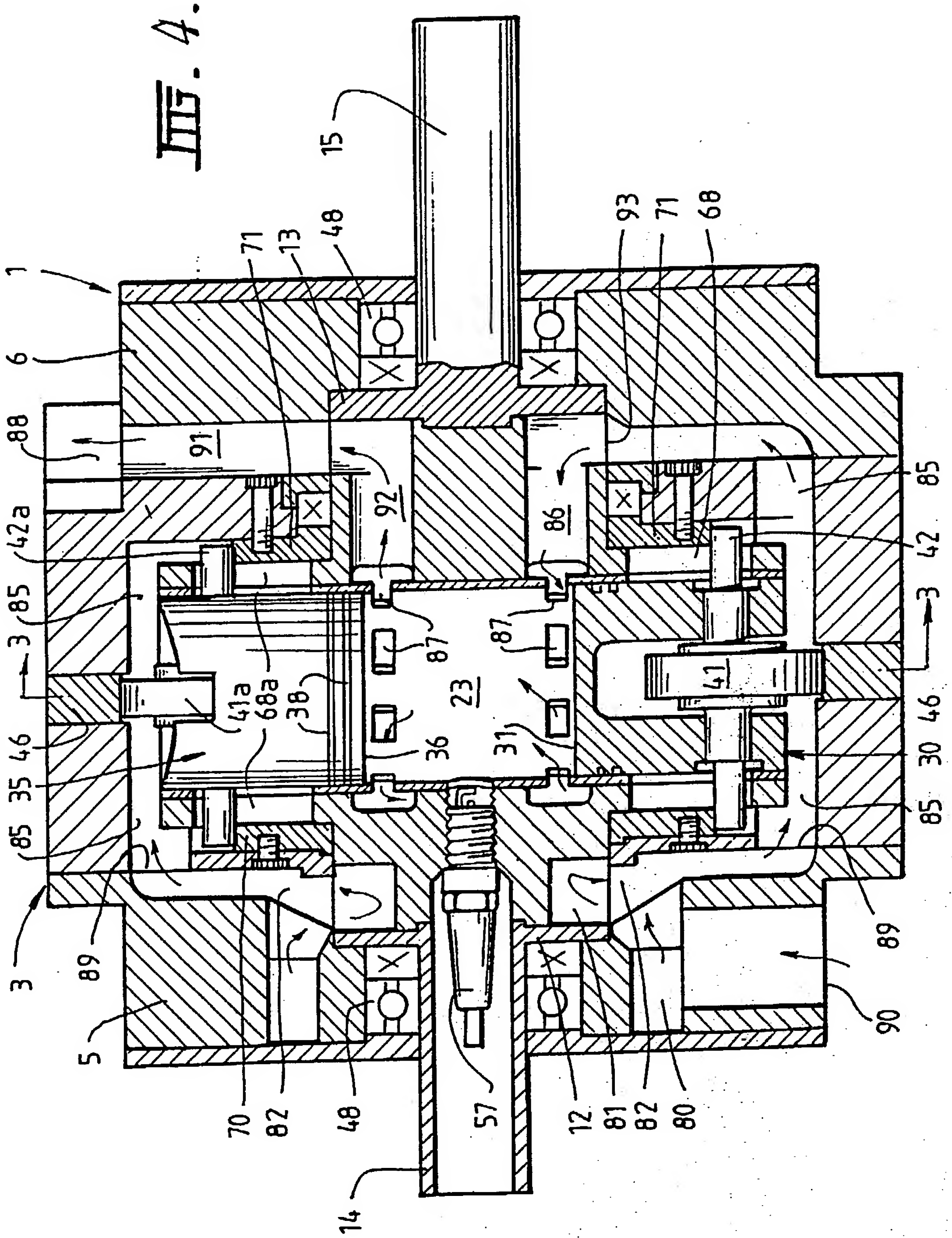

1
6
88
91
42a
85
3
46
35
85
3
89
5
70
82
48
57
12
81
82
80
14
71
13
48
15
92
41a
68a
38
36
23
31
87
87
86
93
71
68
85
42
3
41
46
30
85
89
90

FIG. 4.

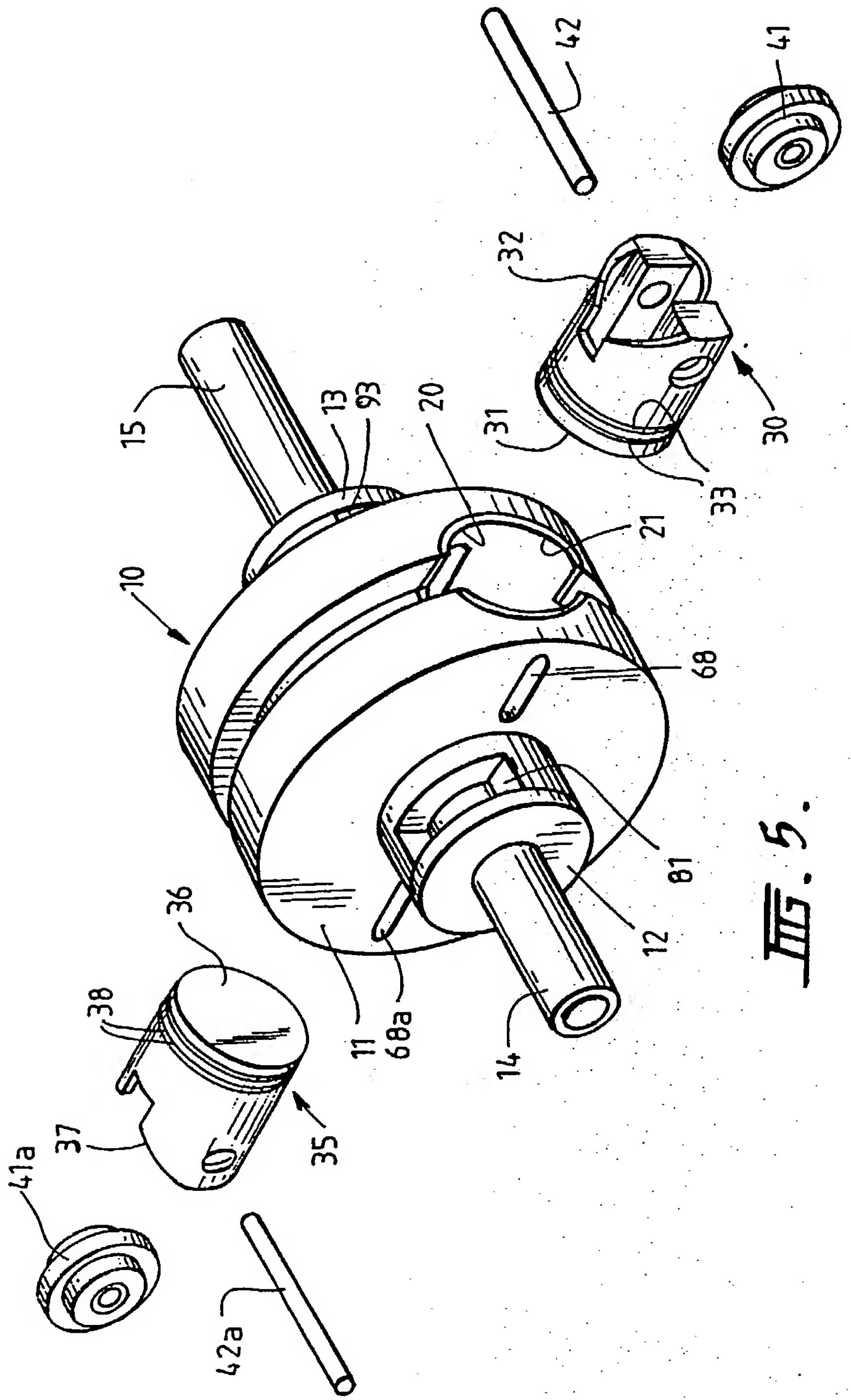

15
13
93
20
31
32
30
33
42
41
10
21
68
81
12
14
11
68a
36
38
35
37
41a
42a

FIG. 5.

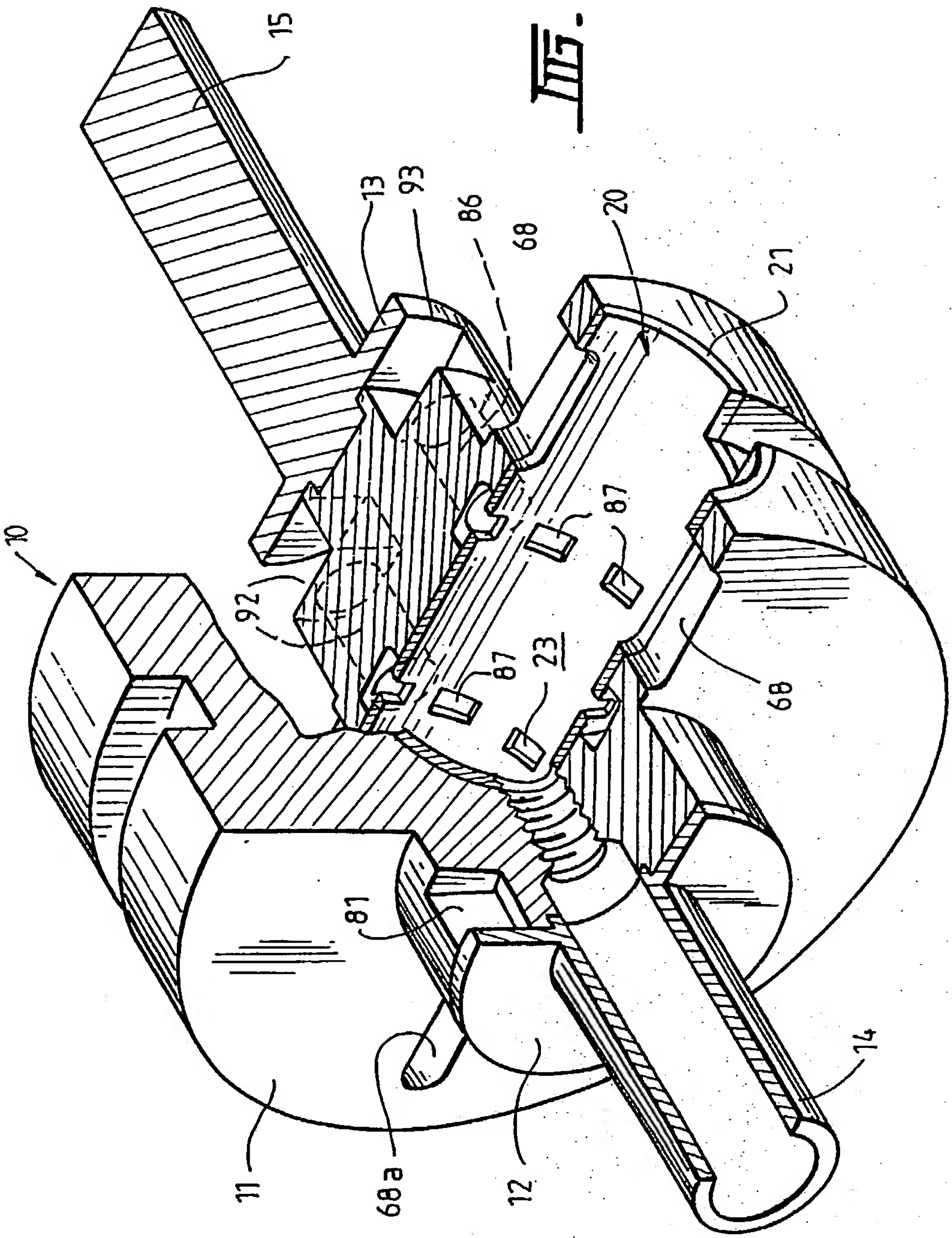


FIG. 6.

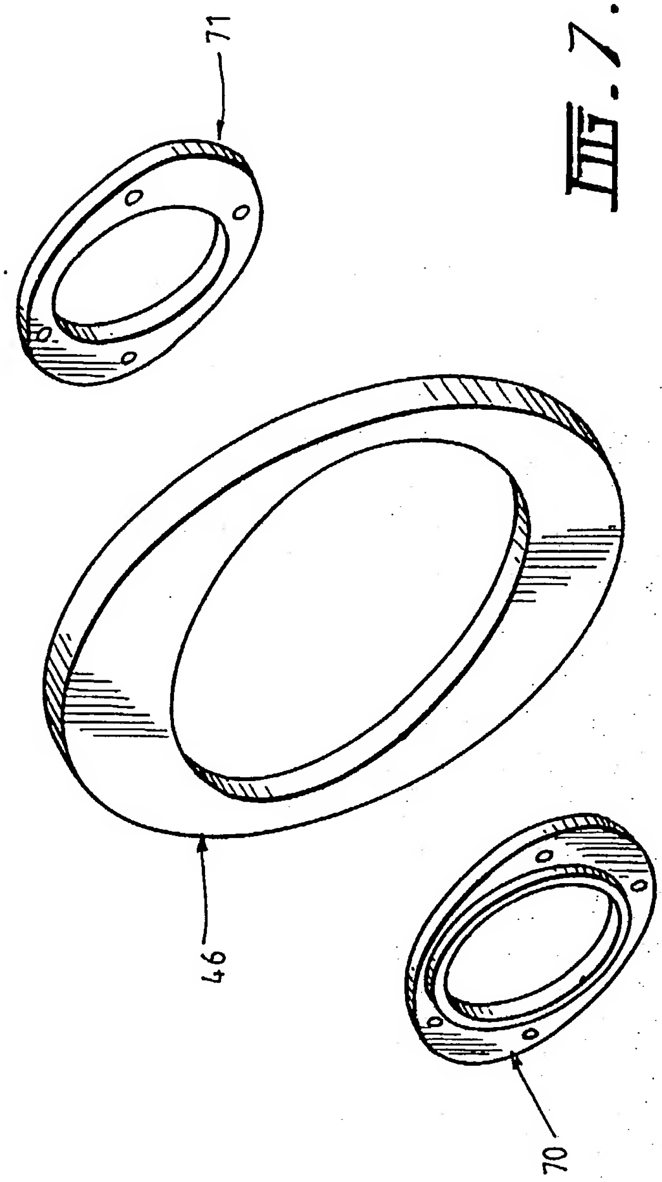


FIG. 7.

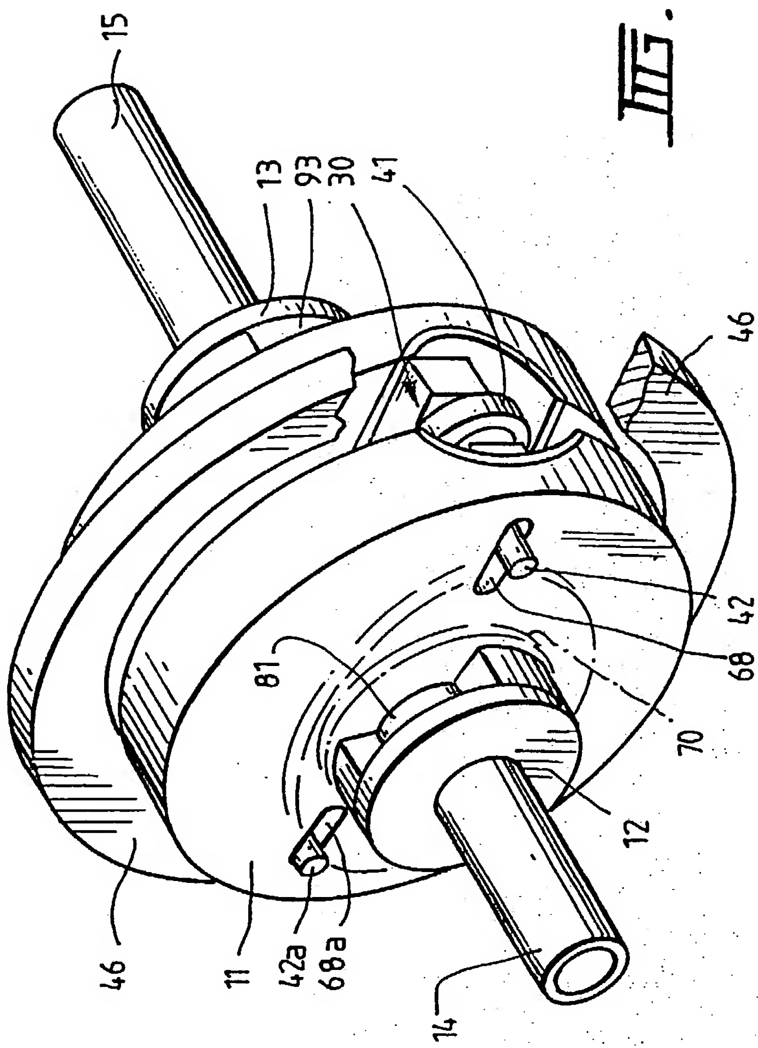


FIG. 8.

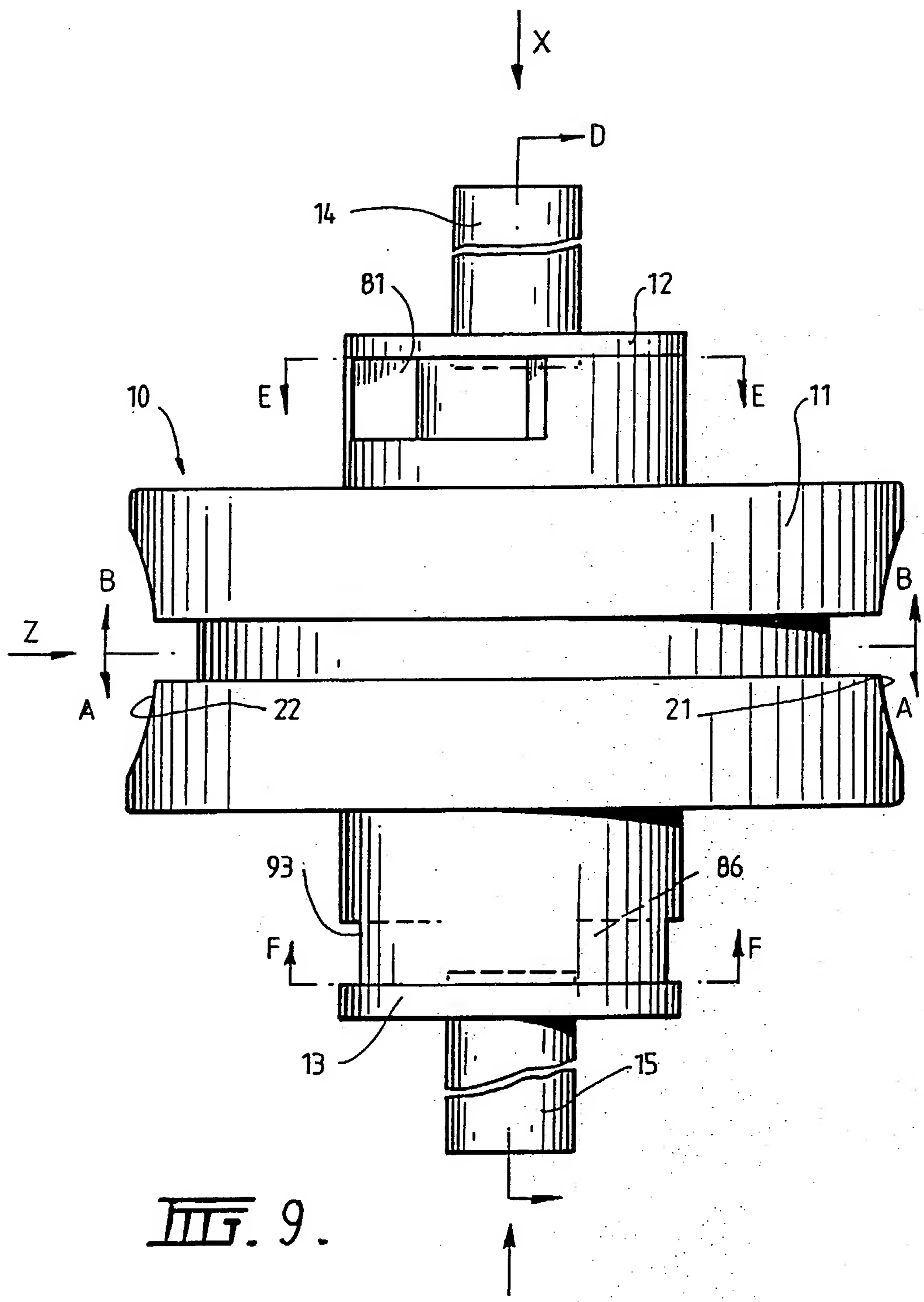


FIG. 9.

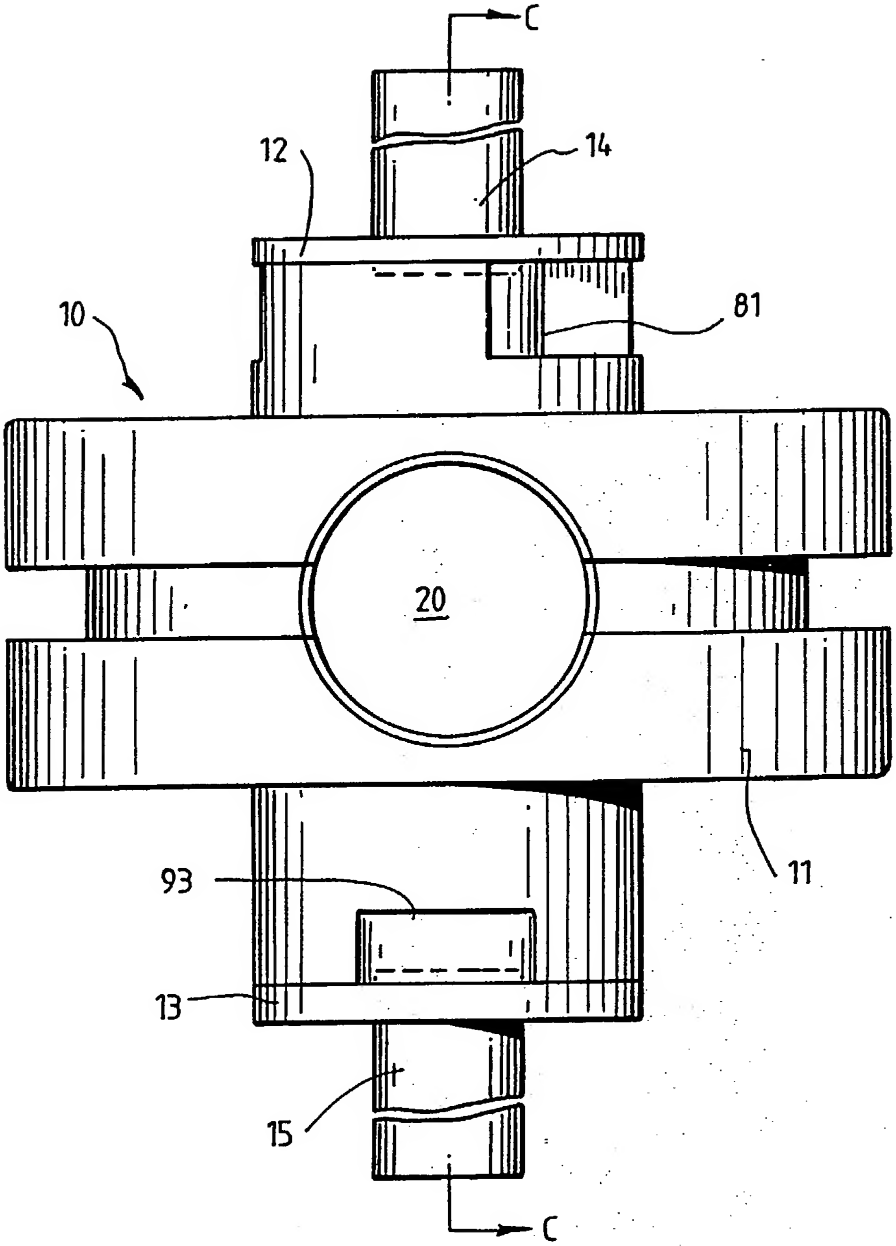


FIG. 10.

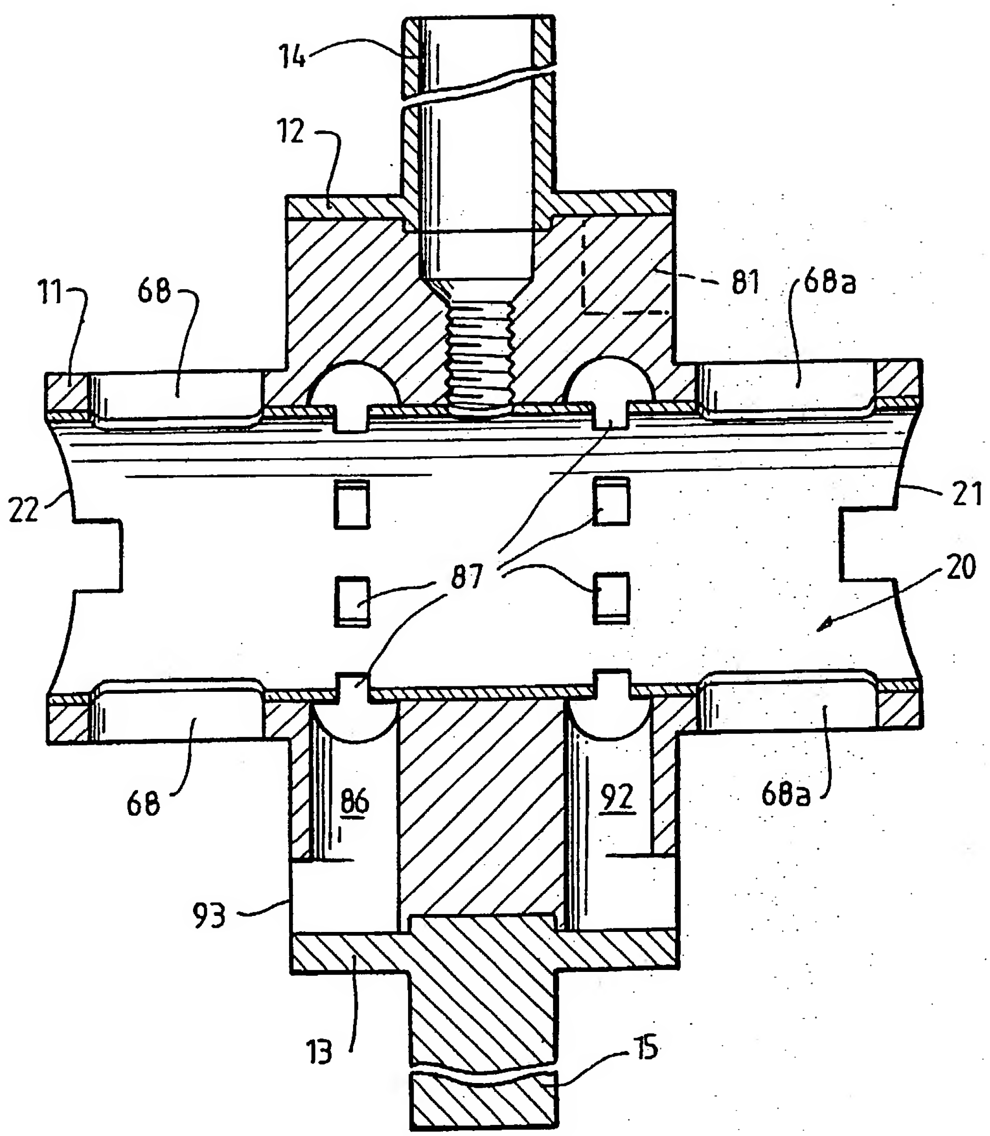


FIG. 11.

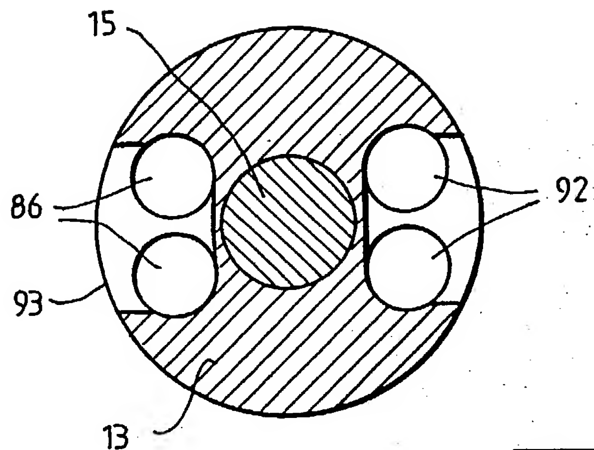


FIG. 12.

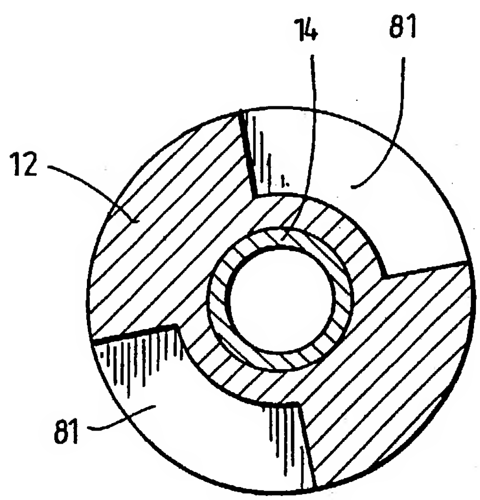


FIG. 13.

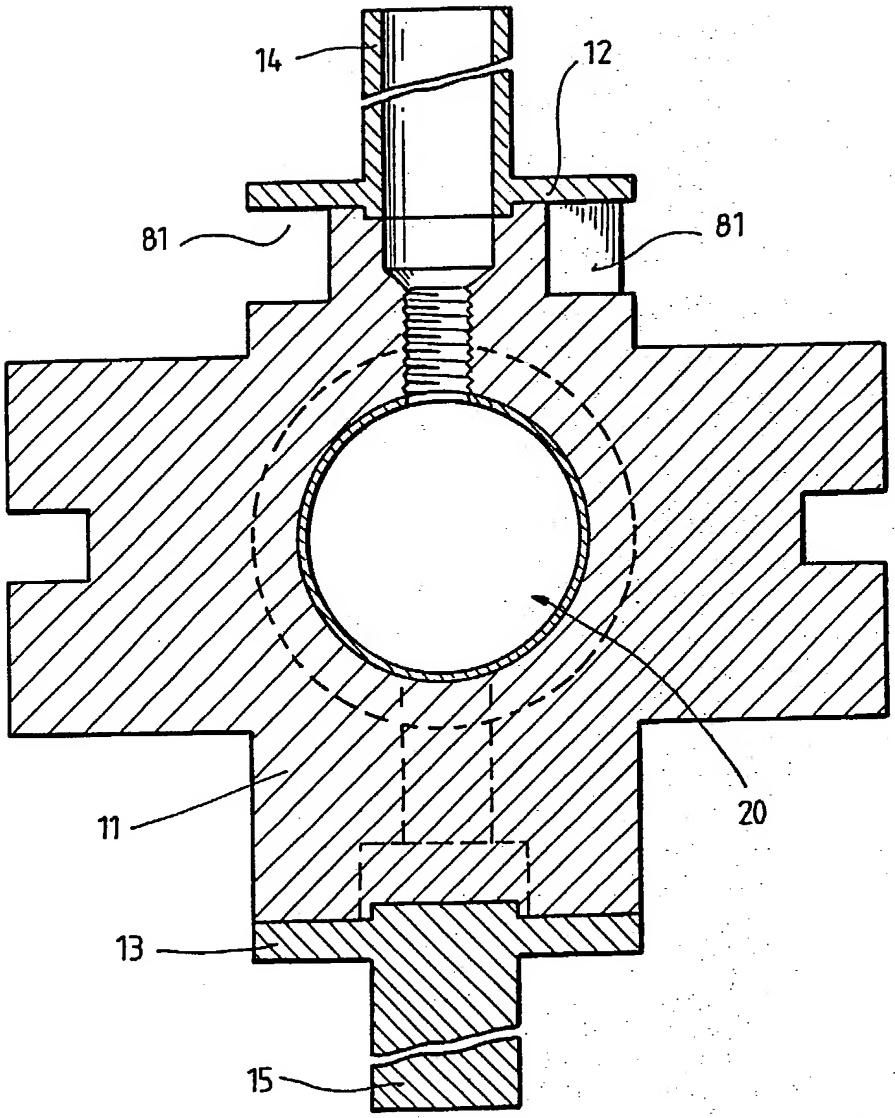


FIG. 14.

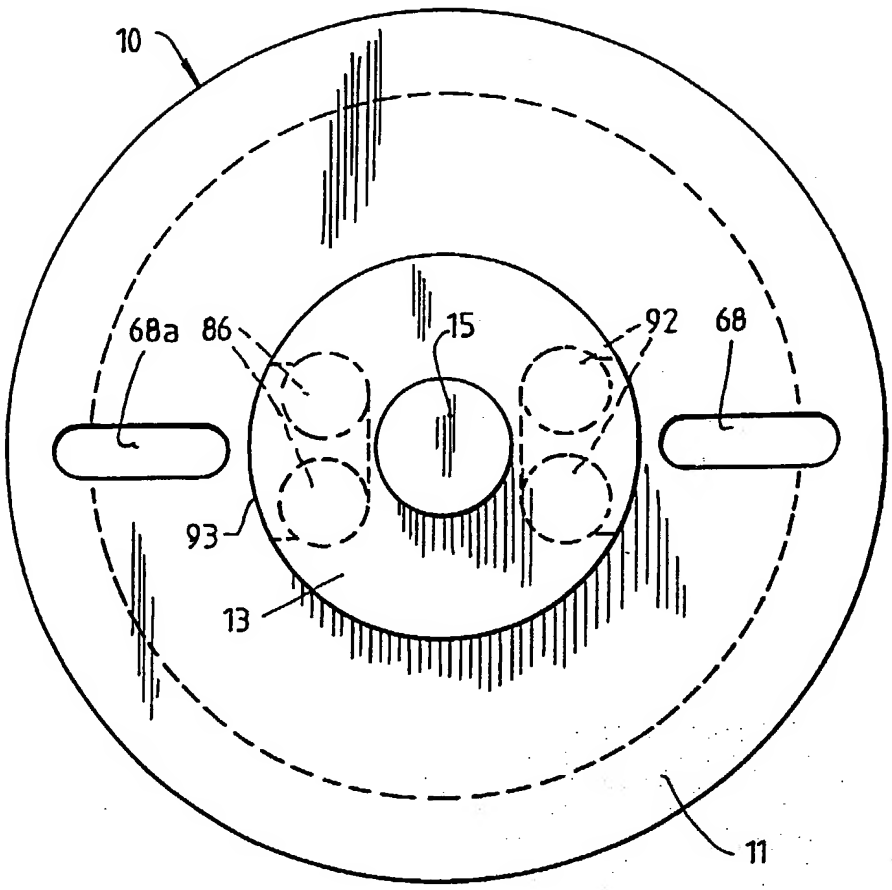


FIG. 15.

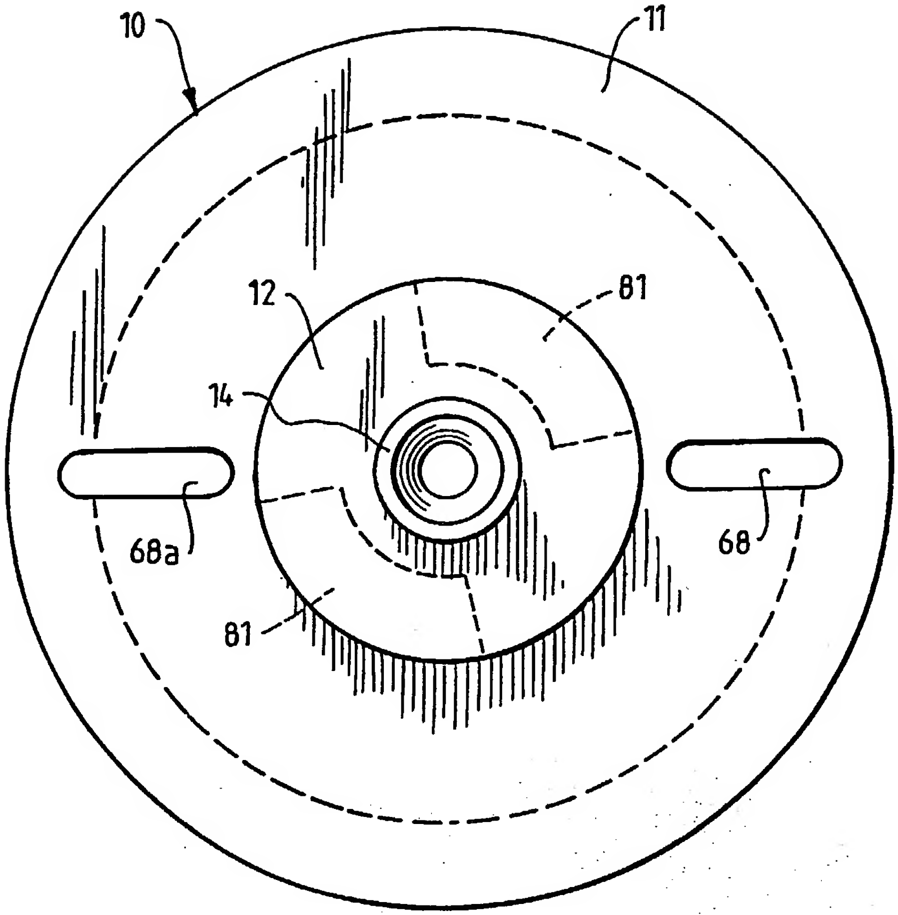


FIG. 16.

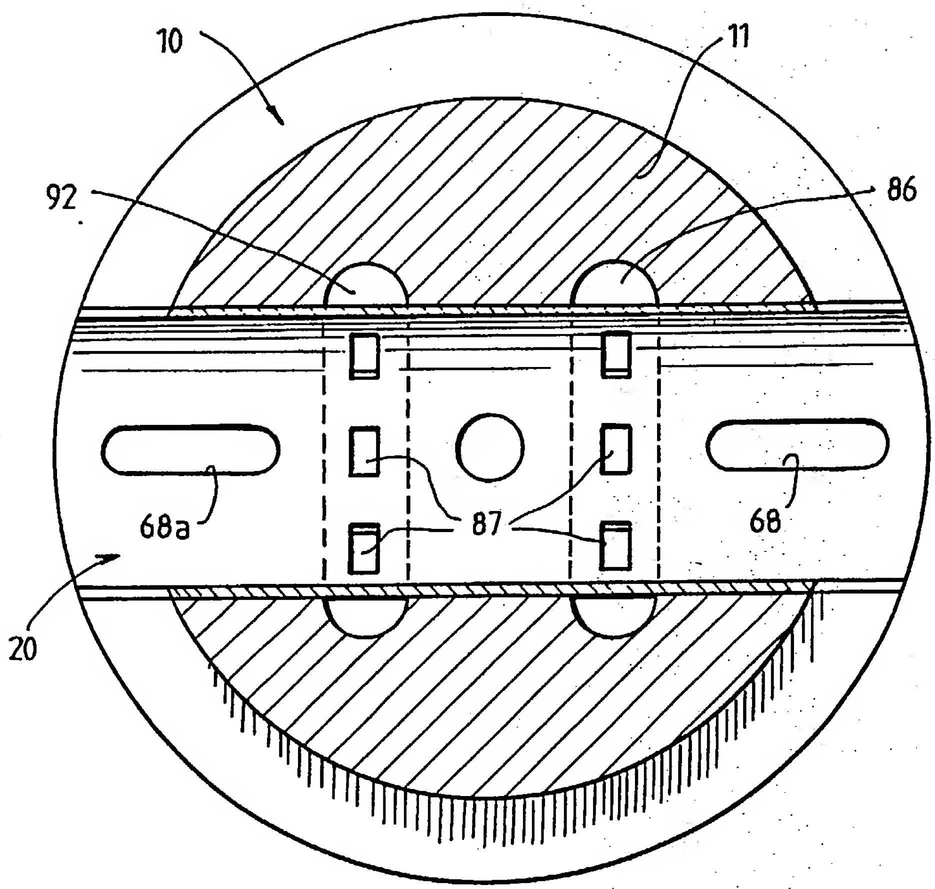


FIG. 17.

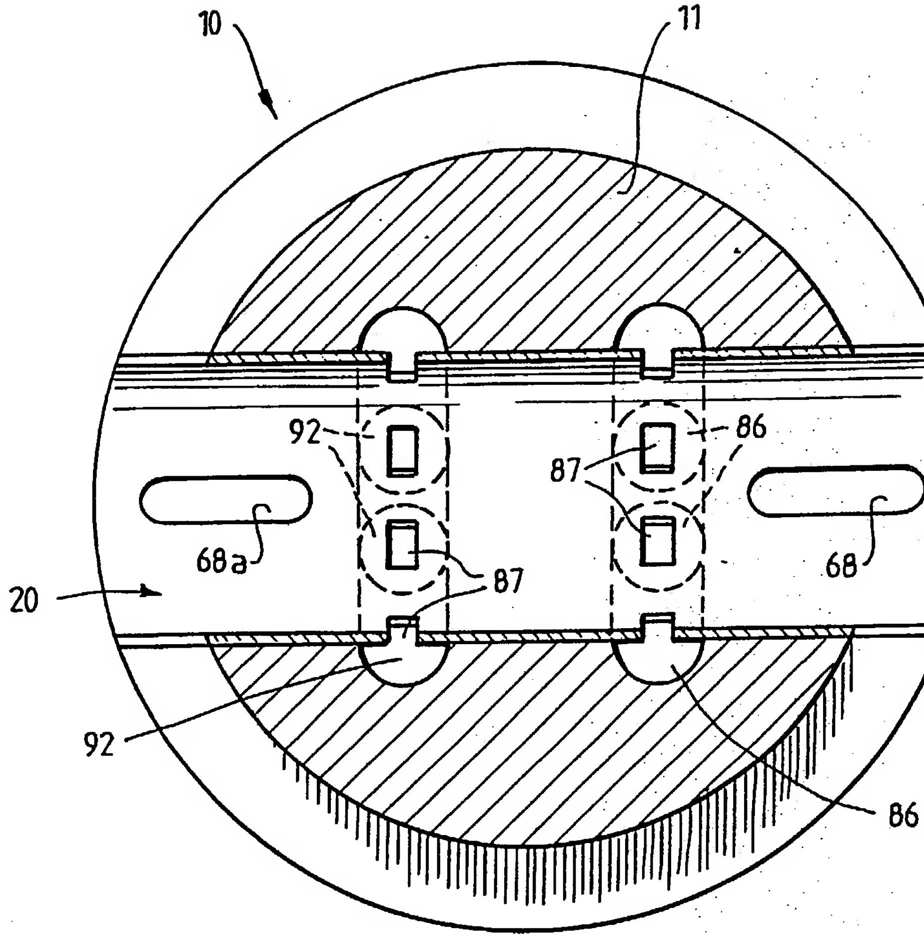


FIG. 18.

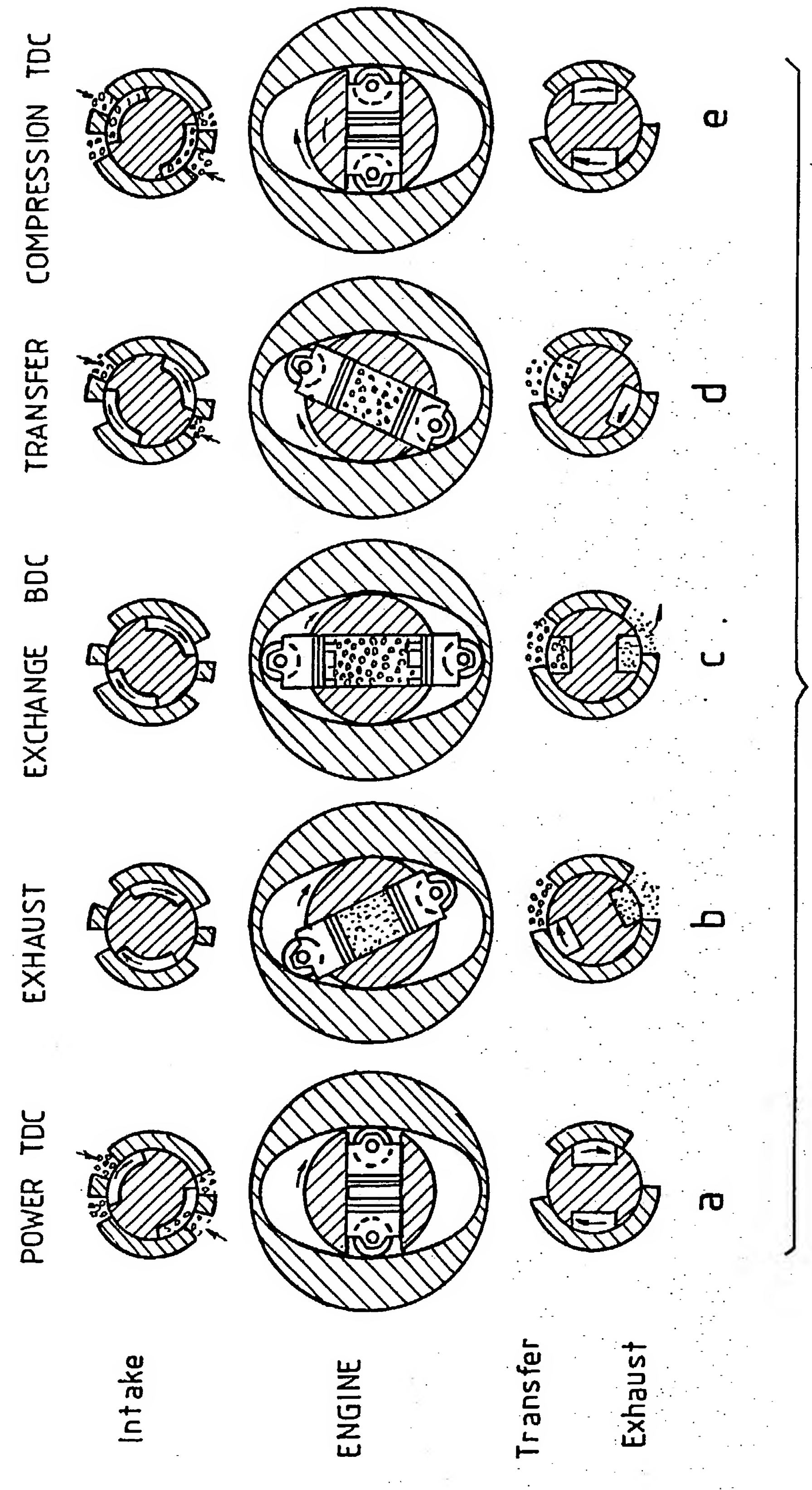

POWER TDC
EXHAUST
EXCHANGE BDC
TRANSFER
COMPRESSION TDC
Intake
ENGINE
Transfer
Exhaust
a
b
c
d
e

FIG. 19.

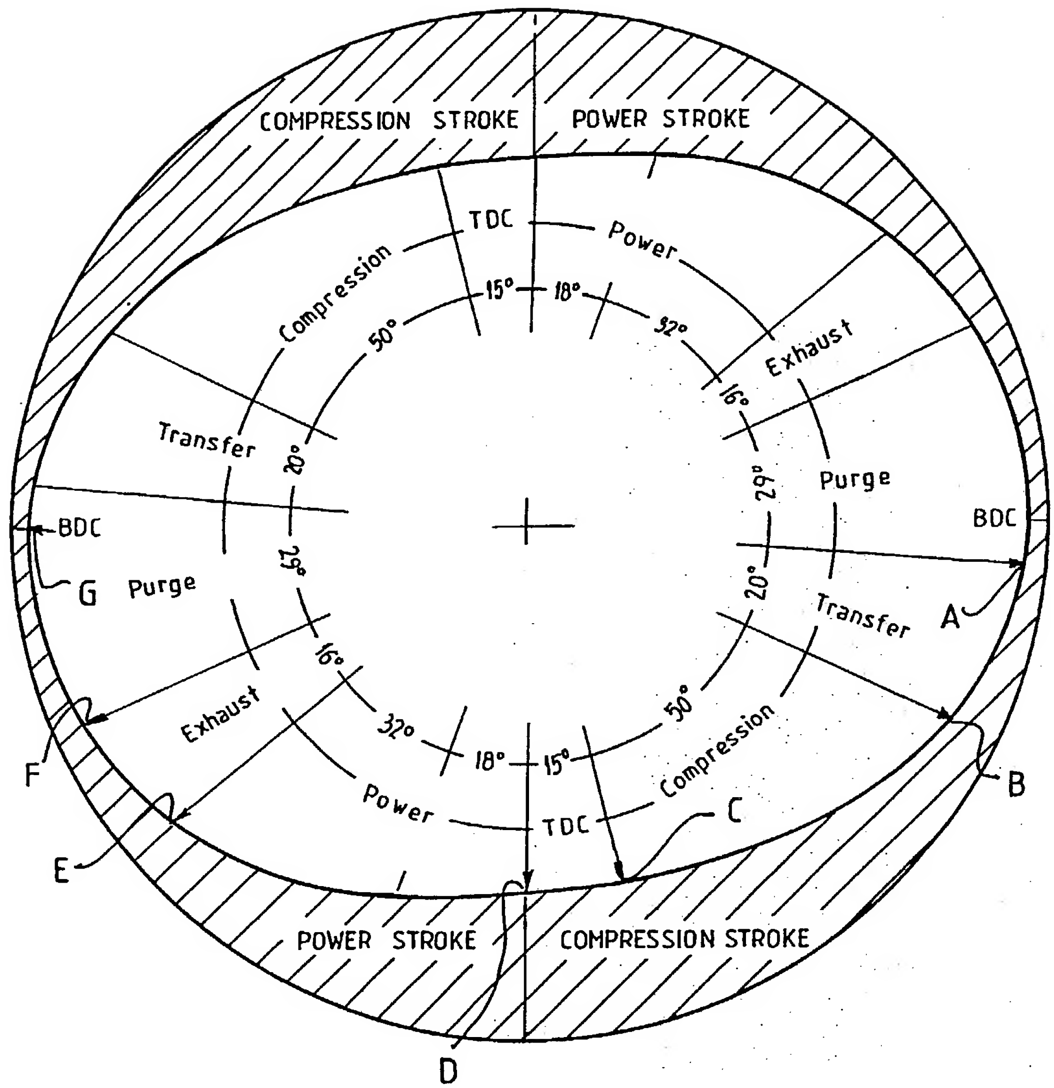

COMPRESSION STROKE
POWER STROKE
TDC
Power
Compression
15°
18°
32°
50°
Exhaust
16°
Transfer
20°
29°
Purge
BDC
BDC
G
Purge
29°
20°
Transfer
A
16°
Exhaust
50°
Compression
32°
18°
15°
F
B
Power
TDC
C
E
POWER STROKE
COMPRESSION STROKE
D

FIG. 20.